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ABSTRACT

The present invention relates to improvements in and relating to moulding materials, and more particularly, to materials for use in rotational moulding, and to products produced thereby.

A first aspect of the invention provides a composite rotational moulding material which includes at least two polyethylenes, at least one of which is a polyethylene produced by metallocene technology, and a suitable stabilisation package, the moulding material having a density range from about 0.870 g/cm^3 to about 0.960 g/cm^3 and having an MFI range of between about 1.5 and about 30.0 g/10 mins.

A further aspect provides a composite rotational moulding material which includes at least one polyethylene produced by metallocene technology and at least one polyethylene not produced by metallocene technology, and a suitable stabilisation package, the moulding material having a density range from about 0.870 g/cm^3 to about 0.960 g/cm^3 and having an MFI range of between about 1.5 and about 30.0 g/10 mins.

The invention also provides a rotationally moulded product produced from a moulding material including at least 2 polyethylenes, at least one of which is produced using metallocene technology, and a suitable stabilisation package, the rotationally moulded product having a Modulus of Elasticity of above about 900 MPa.

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COMPLETE SPECIFICATION

FOR A STANDARD PATENT

ORIGINAL

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Invention Title: 'A MOULDING MATERIAL'

The following statement is a full description of this invention, including the best method of performing it known to me/us:-

File: 21935.00

MOULDING MATERIAL

TECHNICAL FIELD

The present invention relates to improvements in and relating to moulding materials, and more particularly, to materials for use in rotational moulding, and to products produced thereby.

BACKGROUND

Rotational moulding is a method for producing hollow plastic articles. The process was developed in the 1940's but in the early years it attracted little attention because it was regarded as a slow process which was restricted to a small number of plastics. However, over the past two decades, improvements in process control and developments with plastic powders have resulted in a very significant increase in usage of the process. Nowadays the advantages which it has to offer in terms of the economic production of quite complex, stress-free articles has made it a very competitive alternative to blow moulding and injection moulding.

Rotational moulding, also known as rotocasting or rotomoulding, is unique amongst plastics moulding processes because the heating, shaping and cooling of the plastic all take place inside the mould with no application of pressure. The concept is simple. A predetermined charge of cold plastic powder is placed in one 'half' of a cold mould - usually sheet steel or cast aluminium. The mould is then closed and rotated biaxially in a heated oven. As the metal mould becomes very hot, the plastic powder tumbling inside the mould starts to melt and coat the inside surface of the mould. When all the powder has melted, the mould is then transferred to a cooled environment. The biaxial rotation continues until the plastic has solidified. At this point the mould is opened and the product is removed. The article being produced need not be hollow since finishing operations such as cutting or sawing can be used to make, for example, right and left handed articles as will be known to a person skilled in the art.

In rotational moulding, numerous plastics materials are commonly utilised however, predominantly, certain grades of polyethylene are used as the plastics material in the plastic powder referred to above. Typically, a powder produced with such polyethylene grades for use in rotational moulding would have a maximum density of 0.940 with an Melt Flow Index (MFI) of around 3-4.

The (MFI) or Melt Flow Rate (MFR) is obtained under conditions of testing as specified in ASTM D-1238 (or ISO 1133). The number granted is the weight of material (in grams) which would flow through a standard orifice at a standard temperature (190°C) in 10 minutes. The load applied is normally 2.16kg.

In selecting polyethylenes for use in rotational moulding processes to give better performance (i.e. impact, elasticity, broad cure windows), it has been the case that low density grades have been chosen to produce a powder as discussed above. In many moulded products, a high impact product performance is required. This can be the case for example in the manufacture of sporting goods, including kayaks. While known moulding materials and processes can achieve a suitably high impact product performance, this is achieved only to a limited degree and under relatively long cycle times and within a narrower cure window. The moulding material and products of the present invention have application throughout innumerable moulding operations and for moulded products having a variety of uses.

OBJECT OF THE INVENTION

It is an object of the present invention to provide a moulding material which will overcome or at least obviate problems in moulding materials available to the present time, or which at least will provide the public with a useful choice.

Further objects of this invention will become apparent from the following description.

SUMMARY OF THE INVENTION

The invention in a first aspect is a composite rotational moulding material which includes at least two polyethylenes, at least one of which is a polyethylene produced by metallocene technology, and a suitable stabilisation package, the moulding material having a density range from about 0.870 g/cm^3 to about 0.960 g/cm^3 and having an MFI range of between about 1.5 and about 30.0 g/10mins.

The invention in a second aspect is a composite rotational moulding material which includes at least one polyethylene produced by metallocene technology and at least one polyethylene not produced by metallocene technology, and a suitable stabilisation package, the moulding material having a density range from about 0.870 g/cm^3 to about 0.960 g/cm^3 and having an MFI range of between about 1.5 and about 30.0 g/10mins.

Preferably the MFI range at the upper density limit will be between about 1.5 and 20.0 g/10mins.

Preferably the MFI range is between about 1.5 and 10g/10mins.

Preferably the polyethylene not produced by metallocene technology is a high density polyethylene.

The invention in a third aspect is a rotational moulding material which includes at least two polyethylenes at least one of which is produced using metallocene technology, and a suitable stabilisation package, the moulding material having an MFI of at least about 5.0g/10mins and a density of at least about 0.940 g/cm^3.

Preferably the moulding material includes at least one polyethylene produced by metallocene technology and at least one polyethylene not produced by metallocene technology.

Preferably the moulding material has a density of approximately 0.945 and/or an MFI of approximately 5.5.

Preferably the moulding material further includes a suitable pigment.

Preferably the stabilising package includes an antioxidant and/or a UV stabiliser.

Preferably the pigment has a high colour light fastness.

Preferably the pigment has a blue wool scale of between about 7 and about 8 and/or a decomposition temperature of not less than about 250°C.

Preferably the antioxidant is selected from the sterically hindered phenols, phosphites and phosphonites.

Preferably the UV stabiliser is selected from the Hindered Amine Light Stabilisers (HALS).

The invention in a further aspect is a rotationally moulded product produced from a moulding material including at least 2 polyethylenes, at least one of which is produced using metallocene technology, and a suitable stabilisation package, the rotationally moulded product having a Modulus of Elasticity of above about 900 MPa.

Preferably the moulding material has an MFI of at least about 5.0 and a density of at least about 0.940.

Preferably the Modulus of Elasticity is above about 950 MPa and more preferably above about 1000 MPa.

Preferably the rotationally moulded product has an ARM impact cure window of at least about 8 minutes at a strength of at least 65 ft.lb.

The invention in another aspect is a method of producing a rotationally moulded product having a Modulus of Elasticity above 900 MPa, the method including the use of a moulding material which includes at least two polyethylenes, at least one of which is produced using metallocene technology, and a suitable stabilisation package, to provide a moulding material having an MFI of at least 5.0 and a density of at least 0.940, and wherein the moulding material is blended by melt compounding.

DRAWINGS

Preferred forms of the invention will be discussed with reference to the attached Figures. In the Figures:

Figures 1 to 5	show ARM Impact cure window comparisons for Cotene 3990 produced products as produced by the invention, and standard rotationally moulded products (Failure : D = Ductile : B = Brittle);
Figure 6	shows a comparison table of the physical characteristics of Cotene 3990 and two standard rotationally moulded materials.
Figure 7	shows an ARM impact cure window comparison of a standard product (9046/833A) and a product produced using a mould material according to the invention (TN1/335).

DETAILED DESCRIPTION OF THE INVENTION

Rotational moulding, as well as other moulding techniques such as injection moulding, is a well-known method of producing plastics

materials for use in a variety of products. Numerous starting materials can be commonly used in these moulding techniques but the predominant compounds of use are varieties of grades of polyethylene.

In known rotational moulding processing, the polyethylene grades used are selected to produce a powder of plastics material having a maximum density of $0.940 g/cm^3$ and also have a Melt Flow Index (MFI) of around 3-4g/10mins. This plastics material, for use in rotational moulding, produced from the polyethylene grades is usually in a granular or a powder form and is referred to herein as the moulding material.

The polyethylene grades used in injection moulding processing will typically result in a powder having a higher density and MFI.

The reason for the use of the differing polyethylene grades in rotational and injection moulding processes is the different specific processing conditions used and the final application to which the product will be put, and hence the demand on the material properties.

It has surprisingly been found that by combining a polyethylene produced by metallocene technology with a polyethylene not produced by metallocene technology, a rotationally moulded product may be produced which provides unexpectedly good flow properties with high stiffness and high impact resistance. Such a material could conveniently be referred to as a metallocene blend. It has also surprisingly been found that by combining two polyethylenes produced by metallocene technology, one polyethylene being of higher density than the other, similar advantages are obtainable. This is a less preferred option however mainly due to the expense of using metallocene produced polyethylenes. Metallocene polyethylenes will usually be used in lower volume than the non-metallocene produced polyethylenes due to the expense but this is not essential. The non-metallocene produced polyethylene could therefore be seen to be a diluent but the combination produces a number of unexpected beneficial results in the product produced, the processing area, or both. For example, it has been found

that a product can be produced which has a Modulus of Elasticity of above about 900 MPa and/or which has higher ARM impact strength and broader cure window than products produced using metallocene alone or non-metallocene produced polyethylenes alone. The Modulus of Elasticity can exceed 950 MPa and is more preferably above 1000 MPa. This can be contrasted with Modulus of Elasticity readings for rotationally moulded products produced using the usual polyethylene grades which tend to be below 850 MPa. Thus the combination using at least one metallocene produced polyethylene produced a product having enhanced physical characteristics. Preferably the metallocene produced polyethylene is combined with a high density polyethylene (HDPE). Such polyethylenes are well known in the art. The composite moulding material therefore preferably includes a metallocene produced polyethylene and a polyethylene produced by an alternative method. These non-metallocene produced polyethylenes can be grades of polyethylene which are normally used in rotational moulding but can also be grades not normally used.

A measure of Modulus of Elasticity is obtained from a stress-strain curve. A high Modulus of Elasticity typically represents a rigid or tough material which, when combined with the yield elongation, is able to withstand shock loading without brittle failure. The high Modulus of Elasticity shown by products according to this invention means that the range of structural applications is extended beyond that of standard rotational polyethylene grades.

When such a mixture is used advantageous features in the final product and the production process of high Modulus of Elasticity, high ARM impact levels and broad cure windows may be achieved.

The Metallocene production process will be well-known to a person skilled in this particular art. The process itself involves the standard gas phase fluidised bed route but replacing the Ziegler-Natta catalyst with a single site metallocene catalyst. Suitable metallocene polyethylenes for use in the processes produced by such techniques can be obtained from Dow, Exxon, Mitsui, or Borealis, amongst other suppliers.

The moulding material including at least one metallocene produced polyethylene will preferably have a density range of between about 0.870 and about 0.960 g/cm^3 and an MFI between about 1.5 and about 30.0 g/10mins. However, at the higher densities toward the 0.960 g/cm^3 area, the MFI range is preferably between about 1.5 and about 20.0 g/10mins and most preferably between about 1.5 and 10.0g/10mins. Suitably, the moulding material may have an MFI of at least about 5g/10mins and a density of at least about 0.940g/cm^3.

Preferably the MFI will be about 5.5 and the density about 0.945. Most preferably the moulding material of this invention will have an MFI above about 5.2 and a density above about 0.942. The preferable upper limits are - MFI up to about 7.0g/10mins and density up to about 0.949g/cm^3. The use of colours in the production of the mould material can vary the densities, as known in the art, with the use of a Black colour (via use of Carbon Black) producing a density of about 0.958.

The moulding mixture will include recognised stabilisation packages which are essential for rotational moulding application. These packages will usually include antioxidants and/or UV stabilisers, as well as optional pigmentation. Typical pigments which can be included are Carbon Black, Titanium Dioxide, Phthalocyanates, and Cadmiums. The pigments will preferably have a high colour light fastness with a blue wool scale of between about 7 and 8. As stated above, the inclusion of colours can affect the density of the mould material produced. The decomposition temperature of the pigment used will be preferably not less than about 250°C. Typical antioxidants which can be included are, phosphites, phosphonites, and sterically hindered phenols, and typical UV stabilisers will be the Hindered Amine Light Stabilisers (HALS). Alternatives as will be known in the art can also be used.

The role of these additional components is to stabilise the polyethylenes for the processing conditions and end use applications, plus to provide a suitable aesthetic appearance to the product.

A typical component make-up of a moulding mixture according to the inventions could be:

Metallocene Polyethylene	:	10-20%
High Density Polyethylene (HDPE)	:	78-90%
Antioxidant	:	0.10-0.20%
UV Stabiliser	:	0.15-0.20%
Pigment	:	0.2-1.6%

The HDPE is the significant variable in this table. If all other component variables maximum content is added together, the amount of HDPE required is the minimum (i.e. 78%).

It is preferable that the mould mixture is not overworked (e.g. via the use of a twin screw extruder or the like). The mould mixture is preferably formed by melt compounding the ingredients followed by grinding to produce the powdered, or possibly granular, material desired. Such techniques are well known in the art.

Standard rotational moulding processes have been discussed generally herein in the Background to the Invention. The curing times and temperatures used will vary from product to product as required and as will be well known in the art. Typical curing times will be between about 30 minutes and about 3 hours in general industrial applications, and typical curing temperatures will vary between about 185°C to about 210°C. Standard equipment, temperatures and pressures can be used in the rotational moulding process, as will also be known to a skilled person.

As will be well-known to a person skilled in this particular art, the ARM impact cure window is an important feature of a rotational moulding process. The broader the curing window which can be used to produce a product having a suitable ARM impact strength in the final product, the more suitable the process will be for commercial application. If a suitable ARM impact strength is only obtained within a narrow cure window (oven cycle time, measured in minutes), the less robust the process will be as the process will need to be operated within a narrow window in order to get a suitable product. As will be known to a skilled person the ARM

impact strength is very much dependant on the thickness of the test sample. A good ARM impact strength (ft.lb) level for a 3.2 mm thick sample would be above about 65 ft.lb. However, an ARM impact strength for a 3.2 mm thick sample above 85 ft.lb is an exceptional result and is very preferred if achievable. It is generally considered that an ARM impact strength result below about 40 ft.lb for a 3.2 mm thick sample is unsatisfactory. Preference is for as high an impact strength as possible.

As has been referred to previously herein it has been surprisingly found that the production process is improved by utilising the mould mixture of polyethylene grades in accordance with the present invention, as a cure window of at least 3 minutes, more preferably at least 5 minutes, and more preferably between about 3 and about 8 minutes, at an oven temperature of about 250°C and at a standard arm rotation of about 8/2 rpm, gives an ARM impact strength of above about 65 ft.lb. This is clearly shown in the examples which are discussed later in this document. Thus the production process when used to produce such high ARM impact strength products is considerably robust.

It is also preferable for failure to be due to ductile failure as opposed to brittleness failure because this demonstrates a better ability to deal with shock loading and an ability to avoid instantaneous failure. As can be seen in Example 7 and Figure 7 the surprising benefit can relate to the ability to achieve a high ARM impact strength over a broad cure window with a material of similar characteristics to a known material.

EXAMPLES

The invention will now be described by way of a series of examples of preferred forms of the invention.

Example 1

This example gives a general description of a typical polyethylene mix showing the Melt Flow and density characteristics of the polyethylene components, and the density and MFI details of the mixture. The two

grades of polyethylene identified below are blended together with a stabilising package, providing a moulding material which has the following characteristics:

Density	MFI
0.945	5.5

	Metallocene Polyethylene	High Density Polyethylene
Grades:	Melt flow - 0.90-1.10 Density - 0.9135-0.9165	Melt Flow - 6-8 Density (nominal) - 0.9515-0.9565

Blending Operation: The polyethylene grades are melt compounded with required pigments and recognised stabilisation packages for rotational moulding application including antioxidants and U.V. stabilisers.

Examples 2 to 5

These examples compare the ARM impact cure window for Cotene 3990 and a variety of other commercially available grades. Cotene 3990 is a mould mixture formed in accordance with the present invention is formed and from polyethylene grades as shown in Example 1. The comparative mixtures, Exxon XL0360.01; Orica 705UV; Orica 711 UV; Borealis ME8154; and Samsung R900U are mould mixtures which are made in accordance with known techniques using polyethylenes having lower densities and lower MFI characteristics. The particular make-up (in parts) of the Cotene 3990 mould mixture is:

Standard HDPE	85.0
Metallocene PE	15.0
Antioxidant (Master Batch)	3.5
UV Stabilizer (Master Batch)	3.0
	106.0 (parts)

The rotational moulding process for each of the mould mixtures were the same. The reference to "Master Batch" defines a product containing the AO or UV plus a polyethylene carrier, as supplied as a standard product for use by Ciba Giegy for example. Specific conditions used in the Examples were:

Moulding Conditions

Shot Weight: 1600 grams (3.2mm)

Oven temperature 250°C

ARM rotation 8/2rpm

Testing Conditions

Low temperature -40C

Dart weight: 10 and 15 lb

Examples 2 to 5 - Comparisons between Cotene 3990 and Standard Products

Figure 1 shows the ARM impact cure window for a comparison between Cotene 3990 and Exxon XL0360.01. As can be seen from the figure, Cotene 3990 has a broad ARM impact cure window with failure occurring above or at the ARM impact strength level of 65 ft.lb which extends from 12 minutes through to 20 minutes oven cycle time. It is readily apparent that failure occurs at a level considerably higher when the process and mould mixture according to the invention are used as opposed to the standard methods of production as evidenced by Exxon XL0360.01. Similar results are shown in Fig 2 (Cotene 3990 of Orica 705UV) and Fig 4 (Cotene 3990 of Borealis ME 8154).

As can be seen in Fig 3 (Cotene 3990 cf Orica 711UV) and Fig 5 (Cotene 3990 cf Samsung R900U) standard rotationally moulded products can also provide broad cure windows. It is readily apparent, however, that failure occurs at a significantly lower level with the standard products in comparison to Cotene 3990 and, in the case of Orica 711UV (Fig 3) failure is due mainly to brittle failure.

General Details of some of the standard mould mixtures used are:

GRADE	MFI	DENSITY	COMMENT
Exxon XL0360.01	3.4	0.945	Super linear PE (Hexene based) (Metallocene)
Orica 705UV	5.0	0.935	Standard Hexene PE
Borealis ME8154	3.4	0.940	Standard Butene PE
Borealis ME8168	6.0	0.934	Metallocene very narrow molecular weight PE (hexene based)

Figure 6 gives a consolidated comparison of the products produced by known techniques (i.e. Exxon XL0360.01 and Borealis ME8168) and Cotene 3990 produced using the mould mixture and by the process of the invention. Both products were produced by the process described previously. As can be seen, the advantageous characteristics of Cotene 3990 are high impact strength, very high modulus of elasticity and high yield strength with no appreciable loss of other physical parameters. Parameters given for compression moulded materials in Fig 6 are due to standard parameters being in this form when supplied. Data for compression moulded 3990 is given by way of representative comparison.

It is of note that Exxon XL0360.01 is a combination of at least one metallocene polyethylene and Borealis ME8168 comprises a single metallocene polyethylene.

Example 7

The comparison shown in Figure 7 shows a comparison of a product produced according to the invention against a standard product 9046/833A Pearl Grey at 6.4mm thickness. The thickness used is due to a specific application requirement of which the 9046/833A grade was the benchmark grade.

Materials

1. 9046/833A is a Borealis grade standard PE technology with MFI = 4.0 Density = 0.924

2. TNI/335 is 85 parts standard PE technology and 15 parts Metallocene 1 part UV (Master Batch) with MFI = 4.9 Density = 0.926

Moulding Conditions

Shot Weight 3000g(6.4mm)
Oven Temperature 250°C
Arm rotation 8/2 rpm

Testing Conditions

Low Temperature -40°C
Draft Weight 20lb

[Failure: D = Ductile; B = Brittle]

As seen in Figure 7, the cure window for the TN1/335 produced product remains high in comparison with the standard form of product (9046/833A). The metallocene blend thus allows a more robust process with broader acceptable parameters.

A low temperature (-40°C) ARM impact strength test conducted on samples moulded in R&D. The ARM Impact Cure Window is attached, with TN1/335 compared against 9046/833A Pearl Grey, the bench mark grade. The TN1/335 has comparable impact results with the 9046/833A for cook cycles of 26 minutes or less. Visual inspection of samples, moulded for less than 26 minutes the TN1/335 continued to maintain an impact strength in excess of 150ft.lb with no indication of the material being overcooked i.e. no discolourisation or odour. All results for TN1/335 are in excess of 130 ft.lb with a ductile mode of failure.

An independent additive analysis to test the anti-oxidant package in the trial was conducted on powder and moulded samples. The minimal variability between the primary and secondary antioxidant level indicated the trial was correctly stabilised.

As has been mentioned herein, despite the higher density of around 0.945 up to possibly about 0.949, the moulding material of the present invention has been found to provide an impact window border higher and mainly ductile in failure mode than other moulding materials which are available at the present time. This result is contrary to expectations in that lower density grades of moulding material are usually expected to provide better impact performance. Furthermore, the higher flow properties of the material of the present invention as is shown in Figure 6 means that a much better surface finish can be obtained with a greater ease of process ability. While the moulding material of the present invention is intended to preferably use Metallocene technology based rotational moulding material, it will be appreciated by those skilled in that art that the present invention has a potential for a much wider utilisation.

Where in the foregoing description reference has been made to specific components or integers of the invention having known equivalents, then such equivalents are herein incorporated as if individually set forth.

The foregoing describes the invention including preferred forms thereof. Modifications and alterations as would be obvious to a person skilled in this art are intended to be included within the spirit and the scope of the invention as defined in the attached claims.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:-

1. A composite rotational moulding material which includes at least two polyethylenes, at least one of which is a polyethylene produced by metallocene technology, and a suitable stabilisation package, the moulding material having a density range from about 0.870 g/cm^3 to about 0.960 g/cm^3 and having an MFI range of between about 1.5 and about 30.0 g/10mins.

2. A composite rotational moulding material which includes at least one polyethylene produced by metallocene technology and at least one polyethylene not produced by metallocene technology, and a suitable stabilisation package, the moulding material having a density range of from about 0.870g/cm^3 to about 0.960g/cm^3 and having an MFI range of between about 1.5 and about 30.0g/10mins.

3. The moulding material according to claim 1 or claim 2 wherein the MFI range at the upper density limit will be between about 1.5 and 20.0g/10mins.

4. The moulding material according to claim 1 or claim 2 wherein the MFI range at the upper density limit will be between about 1.5 and 10g/10mins.

5. The moulding material according to any one of the previous claims wherein the polyethylene not produced by metallocene technology is a high density polyethylene.

6. A rotational moulding material which includes at least two polyethylenes, at least one of which is produced using metallocene technology, and a suitable stabilisation package, the moulding material having an MFI of at least about 5.0 g/10mins and a density of at least 0.940g/cm^3.

7. The moulding material according to claim 6 including at least one polyethylene not produced by metallocene technology.

8. The moulding material of any one of the previous claims having a density of approximately 0.945 and/or an MFI of approximately 5.5.

9. The moulding material according to any one of the previous claims further including a suitable pigment.

10. The moulding material according to claim 9 wherein the stabilising package includes an antioxidant and/or a U.V. stabiliser.

11. The moulding material according to claim 9 or claim 10 wherein the pigment has a high colour light fastness.

12. The moulding material of any one of claims 9 to 11 wherein the pigment has a blue wool scale of between about 7 and about 8 and/or a decomposition temperature of not less than about 250°C.

13. The moulding material according to any one of claims 10 to 12 wherein the antioxidant is selected from the sterically hindered phenols, phosphites and phosphonites.

14. The moulding material according to any one of claims 9 to 13 wherein the U.V. stabiliser is selected from the Hindered Amine Light Stabilisers (HALS).

15. A rotationally moulded product produced from a moulding material including at least two polyethylenes, at least one of which is produced using metallocene technology, and a suitable stabilisation package, the rotationally moulded product having a modulus of elasticity of above about 900 MPa.

16. The rotationally moulded product according to claim 15 wherein at least one polyethylene is not produced using metallocene technology.

17. The rotationally moulded product according to claim 15 or claim 16 produced from a moulding material having an MFI of at least about 5.0 and a density of at least about 0.940.

18. The rotationally moulded product according to claim 15, 16 or 17 wherein the modulus of elasticity is above about 950 MPa.

19. The rotationally moulded product according to any one of claims 15 to 18 wherein the modulus of elasticity is above about 1000 MPa.

20. The rotationally moulded product according to any one of claims 15 to 19 having an ARM impact cure window of at least about 8 minutes at a strength of at least 65ft.lb.

21. A composite rotational moulding material according to any one of the previous claims including:

Metallocene Polyethylene	:	10-20%
High Density Polyethylene (HDPE)	:	78-90%
Antioxidant	:	0.10-0.20%
UV Stabiliser	:	0.15-0.20%
Pigment	:	0.2-1.6%

and wherein the HDPE is the significant variable.

22. A method of producing a rotationally moulded product having a modulus of elasticity of above 900 MPa, the method including the use of a moulding material which includes at least two polyethylenes at least one of which is produced using metallocene technology, and a suitable stabilisation package, to provide a moulding material of at 5.0 and a density of at least 0.940, and wherein the moulding material is blended by melt compounding.

23. The method according to claim 22 wherein the moulding material further includes at least one polyethylene not formed using metallocene technology.

24. A composite rotational moulding material substantially as herein described with reference to any one of the examples and attached Figures excluding comparatives.

25. A rotationally moulded product substantially as herein described with reference to any one of the examples or attached Figures excluding comparatives.

26. A method of producing a rotationally moulded product having a modulus of elasticity above 900 MPa substantially as herein described with reference to any one of the examples or attached Figures excluding comparatives.

DATED this 18th Day of March 1999

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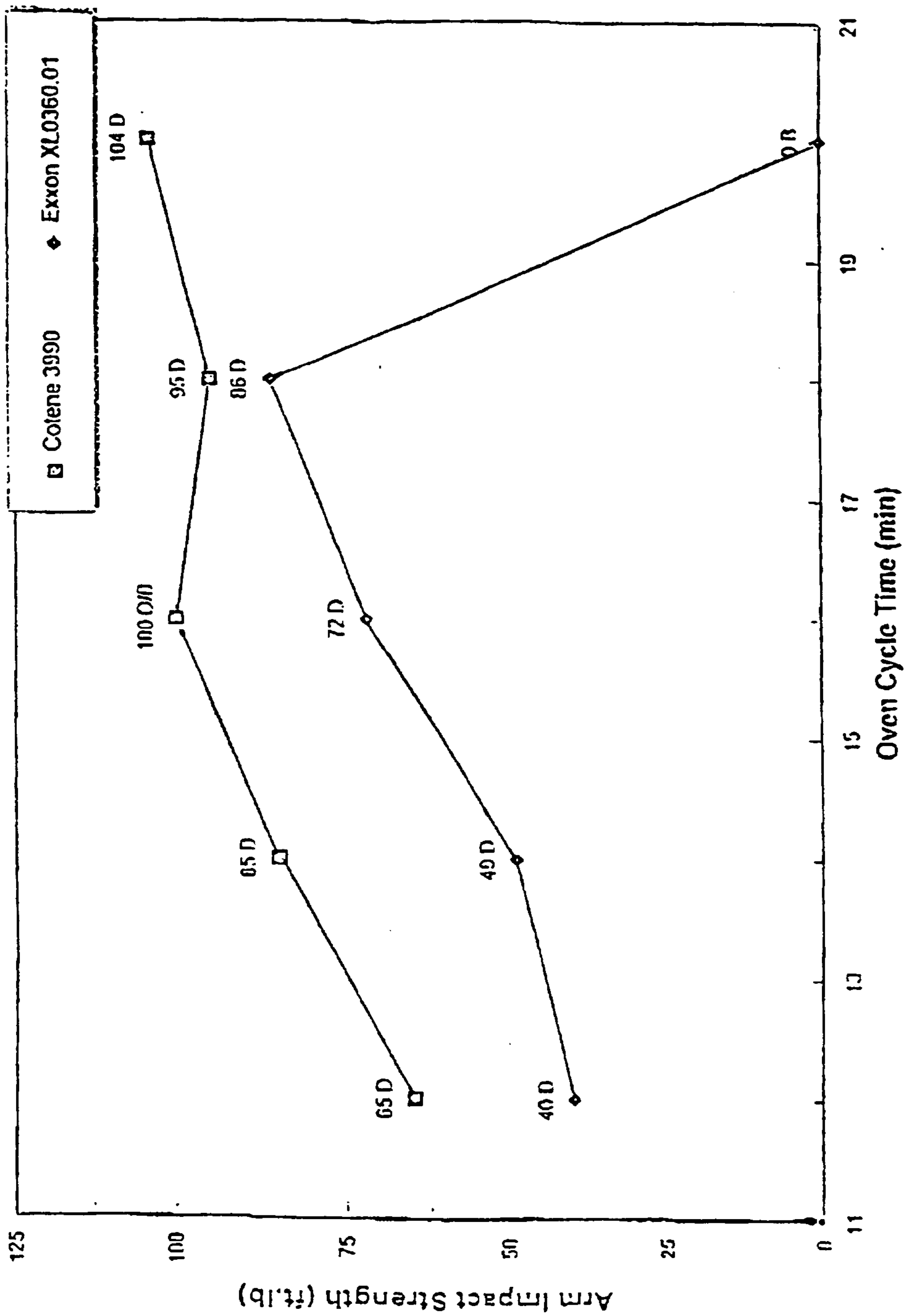

Cotene 3990
Exxon XL0360.01
Arm Impact Strength (ft.lb)
125
100
75
50
25
0
11
13
15
17
19
21
Oven Cycle Time (min)
104 D
95 D
100 D/D
65 D
0 B
86 D
72 D
49 D
40 D

FIGURE 1

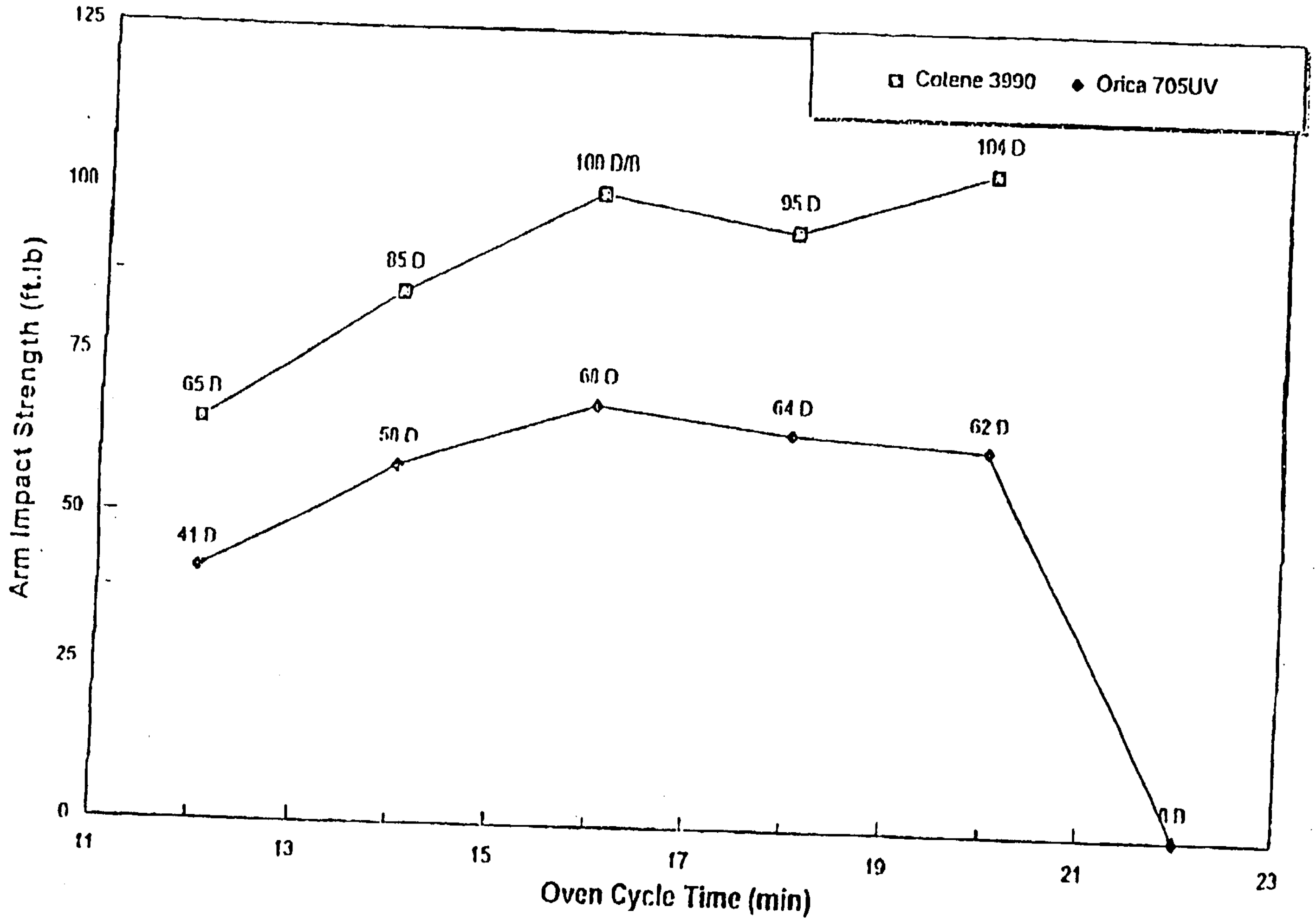
Colene 3990
Orica 705UV
Arm Impact Strength (ft.lb)
125
100
75
50
25
0
11
13
15
17
19
21
23
Oven Cycle Time (min)
65 D
85 D
100 D/B
95 D
104 D
41 D
50 D
60 D
64 D
62 D
0 D

FIGURE 2

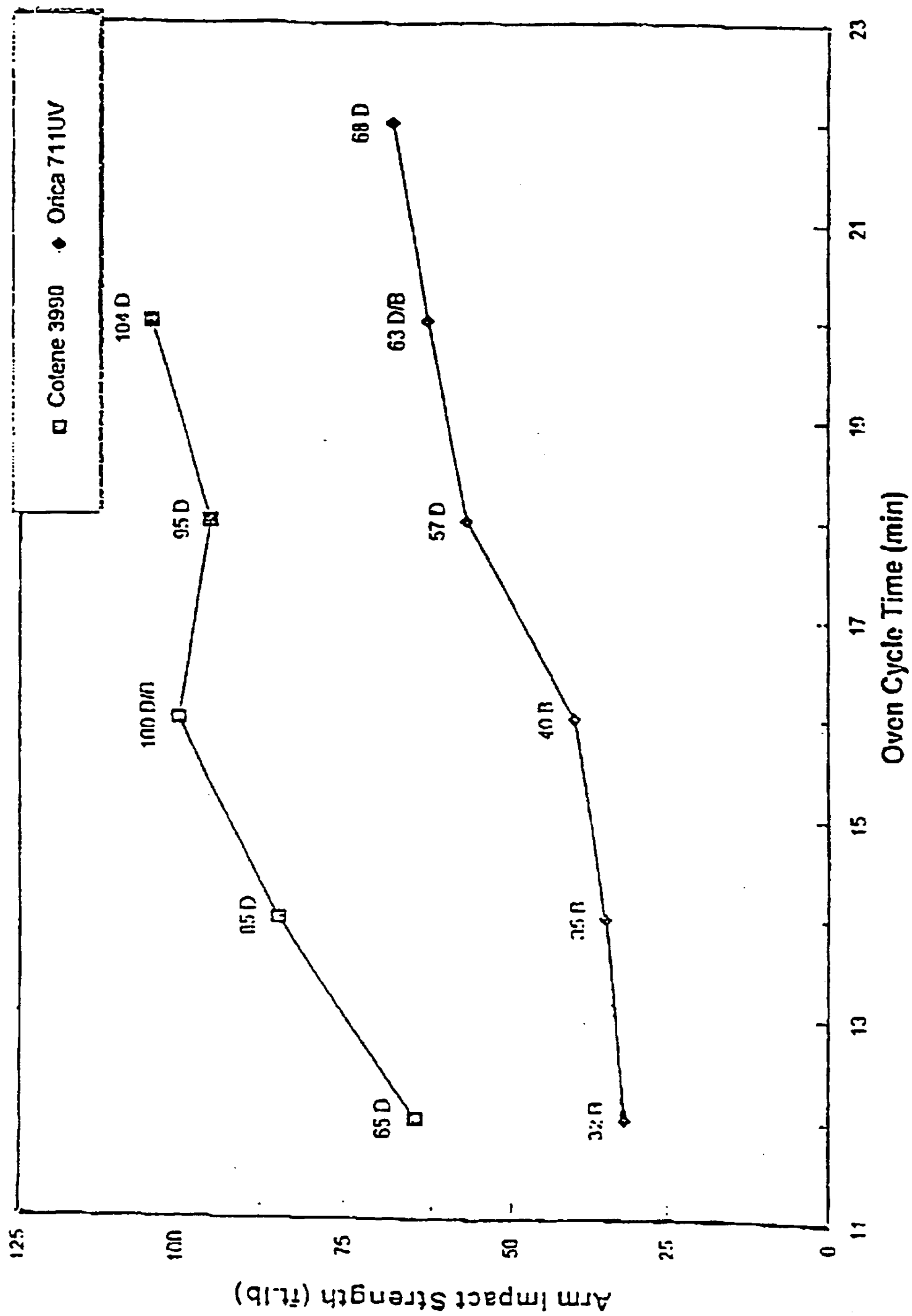
Cotene 3990
Orica 711UV
Arm Impact Strength (ft.lb)
Oven Cycle Time (min)
125
100
75
50
25
0
11
13
15
17
19
21
23
65 D
95 D
104 D
40 B
57 D
63 D/B
68 D

FIGURE 3

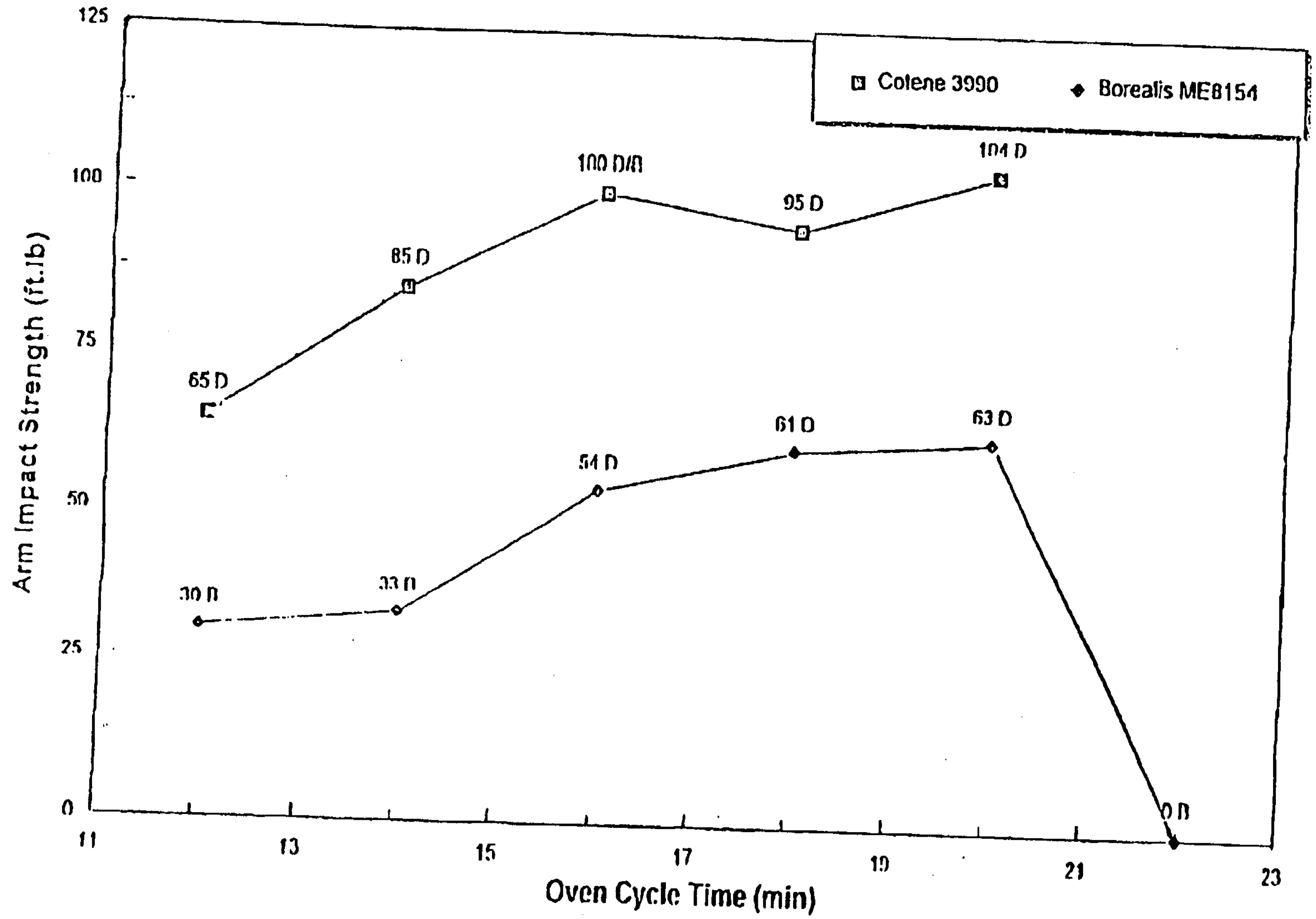
Cotene 3990
Borealis ME8154
100 D/B
104 D
95 D
85 D
65 D
63 D
61 D
54 D
33 D
30 D
0 B
125
100
75
50
25
0
11
13
15
17
19
21
23
Arm Impact Strength (ft.lb)
Oven Cycle Time (min)

FIGURE 4

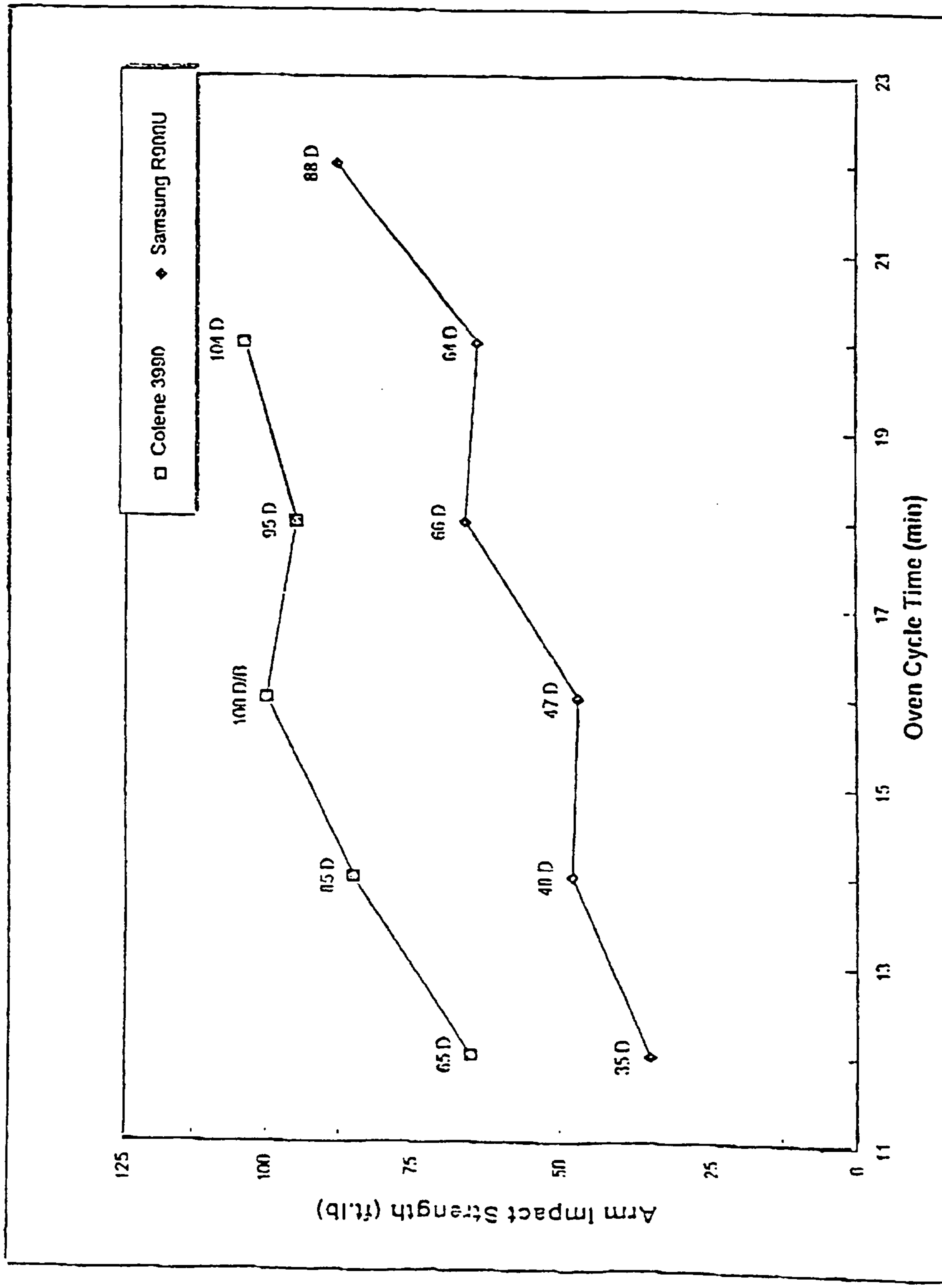
Colene 3990
Samsung R900U
Arm Impact Strength (ft.lb)
125
100
75
50
25
0
11
13
15
17
19
21
23
Oven Cycle Time (min)
65 D
85 D
100 D/B
95 D
104 D
35 D
40 D
47 D
66 D
64 D
88 D

FIGURE 5

FIGURE 6

Comparision Table between 3990, Exxon XL0360.01 and Borealis ME8168

Material Property	Compression Moulded 3990	Rotational Moulded 3990	Compression Moulded Exxon XL0360.01	Rotational Moulded Exxon XL0360.01	Compression Moulded Borealis ME8168	Units	Test Method
Melt Flow Index (MFI)	---	6.1	---	3.5	---	g/10min.	ASTM D1238
Density	---	0.947	---	0.945	---	g/cm³	ASTM D1505
ESCR F50 Cond. A							
100% Igepal	8	---	45	---	>720	Hours	ASTM D1693
10% Igepal	6.7	---	23	---	55	Hours	ASTM D1693
Flexural Modulus	704	703	575	704	452	MPa	ASTM D790
Yield Strength 50mm/min	22.7	24.7	20.4	23.3	17.5	MPa	ASTM D638
Elongation at break 50mm/min	188	199	>280	416	>266	%	ASTM D638
Shore Hardness	65	---	60	---	60	Shore D	ASTM D2240
Softening Point (Vicat)	124	---	123	---	122	°C	ASTM D1525
ARM Impact Strength (3.2mm sample @ -40°C)	---	100	---	85	---	ft.lb.	ARM Method
Tensile Modulus	---	510	---	471	---	MPa	ASTM D638
Shrinkage	---	2.6	---	2.7	---	%	---
Modulus of Elasticity	1,023	---	782	---	707	MPa	ASTM D638
Flexural Yield Stress	21.8	---	17.5	---	16.8	MPa	ASTM D790

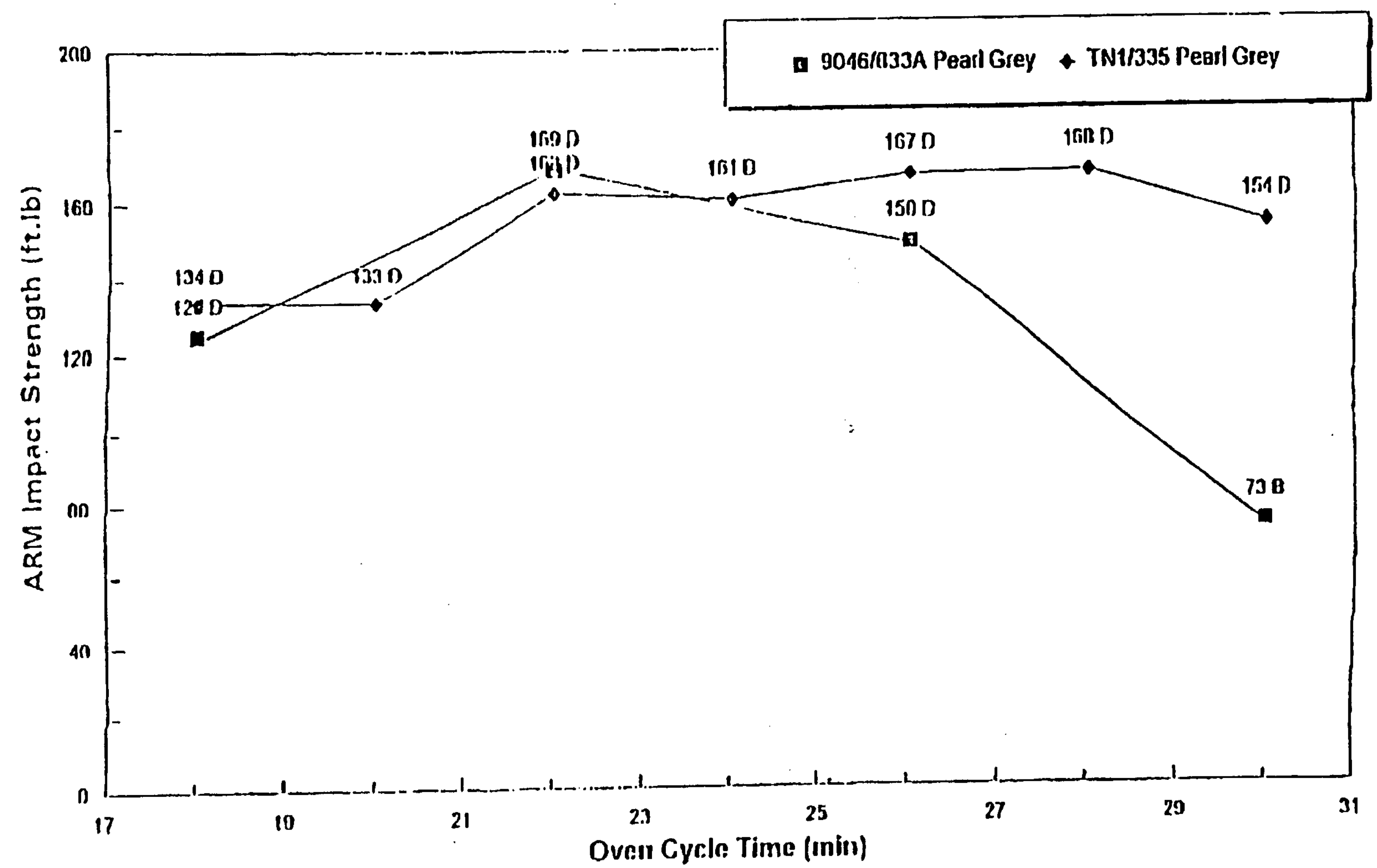
9046/033A Pearl Grey
TN1/335 Pearl Grey
ARM Impact Strength (ft.lb)
Oven Cycle Time (min)
134 D
126 D
133 D
169 D
161 D
167 D
150 D
168 D
154 D
73 B
0
40
120
160
200
17
21
23
25
27
29
31

FIGURE 7